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THE EFFECT OF PEDOMETER STEP GOAL, FEEDBACK AND SELF-MONITORING INTERVENTIONS ON ACCELEROMETER-MEASURED PHYSICAL ACTIVITY IN CHILDREN

Ash C. Routen[1,2], Dominic Upton[3], Martin G. Edwards[4] & Derek M. Peters[1,5]

[1]Institute of Sport & Exercise Science, University of Worcester, UK.
[2]School of Education, Durham University, UK.
[3]Faculty of Health, University of Canberra, Australia.
[4]Institut des Sciences Psychologiques, Université catholique de Louvain, Belgium.
[5]Faculty of Health & Sport Sciences, University of Agder, Kristiansand, Norway.

ABSTRACT

This study assessed the utility of 3-week goal-setting, self-monitoring and step-feedback pedometer interventions for increasing physical activity (PA) in children, and the relative impact of individual and group-standardised goals. Three classes of primary school children (n = 68) were randomised to: (a) individual-standardised goal (IS), (b) group-standardised goal (GS) or (c) open pedometer control (CON) groups. PA was assessed via accelerometry (baseline and end-point). There were no main effects for study group, but there was an interaction between time and group for moderate-to-vigorous PA (MVPA), with MVPA time change differing between IS and CON, as MVPA increased in IS but decreased in CON. Mean plots showed MVPA increased in *less-active* children allocated IS goals, but decreased in GS children. MVPA in *more-active* children did not change in IS, but declined in GS and CON. Goal-setting, self-monitoring and step-feedback pedometer interventions did not modify PA. Individual-standardised goals may, however, have utility due to mitigating the decline in MVPA in *more-active* and increasing MVPA in *less-active* children.

Keywords: Accelerometry; Behavioural science; Intervention study; Pedometry; Youth.

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INTRODUCTION

Regular physical activity (PA) in childhood is associated with a range of physiological and psychological health benefits including lower fat mass (Ness et al., 2007; Riddoch et al., 2009), cardiometabolic risk (Ekelund et al., 2012) and psychiatric difficulties (Martikainen et al., 2012). Recent population level accelerometer data suggests around 50% of primary school-aged children do not attain recommended volumes of health-enhancing moderate-to-vigorous PA (MVPA) (Griffiths et al., 2013). Subsequently, designing and evaluating interventions to increase PA in pre-adolescent children is important.

Pedometers are often used as motivational tools within PA interventions as they provide real-time feedback (step counts) on ambulatory PA. This continual feedback permits the ability to self-regulate behaviour by monitoring and/or recording daily steps and comparing against a reference goal (e.g., 10,000 steps). Evidence from two systematic reviews of studies in adults shows pedometer use can lead to moderate increases in PA over baseline in the order of 2−3,000 steps per day more than controls (Bravata et al., 2007; Kang et al., 2009a). In children, less evidence exists to support pedometer use. Data from studies in children shows that pedometer use is associated with increases in PA of 300−3,000 steps per day (Berry et al., 2007; Hardman et al., 2011; Horne et al., 2009; Kang and Brinthaupt, 2009; Oliver et al., 2006).

Physical activity interventions in children using pedometers have usually employed one, or a combination, of self-monitoring (recording/graphing daily steps), pedometer feedback and step-goal setting alongside additional behavioural strategies (Berry et al., 2007; Hardman et al., 2011; Horne et al., 2009; Oliver et al., 2006). The use of multiple intervention components and poor reporting of pedometer strategies clouds judgement on active intervention ingredients, therefore limiting understanding of how pedometer deployment relates to effectiveness. Few studies have trialled pedometer strategies *per se* in children. Butcher et al. (2007) found a combination of step-count feedback and PA information to increase steps per minute compared with 'no feedback and information' controls. Whilst Kang and Brinthaupt (2009) reported a combination of step feedback, self-monitoring and goal setting was sufficient to increase daily steps by around 19% over baseline (following a 6-week intervention), however a control group was not included. No studies have compared goal setting, step-count feedback and self-monitoring using a step diary against a control group in children.

Likewise there is scant evidence on the importance of step-goal type. A meta-analysis using adult participants (Kang et al., 2009a), found interventions administering pre-set (i.e., 10,000 steps.day^{-1}) goals to elicit a slightly larger effect size than individual-standardised goals (i.e., incremental increases above baseline steps). However, Tudor-Locke and Lutes (2009) suggest that due to limited research comparing goal types, the setting of any goal above baseline values for an individual to work towards may be sufficient to increase PA. The types of step goals that could be administered include self-set (user sets own goal, also known as tailored or personalised), individual-standardised (i.e., increment above individual baseline), group-standardised (i.e., increment above group baseline) or pre-set universally administered (i.e., 10,000 steps.day^{-1}) goals (Tudor-Locke & Lutes, 2009). Only one study has examined differences between step-goal conditions in children (Kang & Brinthaupt, 2009), showing no differences in steps between individual-standardised (+5% of participant's previous 2-week average) and group-standardised (+5% of group's previous 2-week average) goal conditions. Children in both intervention arms were able to view pedometer steps and were instructed to record daily steps in a diary. No further studies have examined the relative impact of different goal types in children.

When evaluating interventions the identification of potential moderating variables on the main intervention effect (e.g., sex, age etc.) should be considered. There have been calls within the pedometer literature for research to determine the effects on children of differing weight status (Horne et al., 2009; Tudor-Locke & Lutes, 2009). Interestingly, differential (and more positive) responses to pedometer interventions have been observed in low-active children and girls (Horne et al., 2009; Oliver et al., 2006). More data on moderating variables is required however.

Therefore, the first aim of the present study was to determine the impact of a 3-week school-based intervention employing pedometer goal setting, step-count feedback and self-monitoring on accelerometer-measured physical activity in Year 6 children. The second aim was to determine the relative impact of individual-standardised and group-standardised step goal conditions, and examine if intervention response differed by weight status or baseline physical activity.

METHODS

Participants

Sixty-eight Year 6 children (boys: n = 27; height: 146.9 ± 7.7 cm; weight: 40.0 ± 7.6 kg; BMI: 18.5 ± 2.7 kg.m^2; girls: n = 41; height: 145.6 ± 7.2 cm; weight: 41.5 ± 11.6 kg; BMI: 19.3 ± 4.1 kg.m^2) aged 11.2 ± 0.3 years were recruited from two primary schools in the West Midlands region of England. The experimental protocol received institutional ethics committee approval, and written parental consent and child assent were obtained prior to participants enrolling.

Sample size

G-power software (Version 3.1.3) was used to calculate the required sample size for the primary outcome of time spent in MVPA. The statistical test was set at *F*-test repeated-measures ANOVA within-between group design, the alpha level was set at 0.05, the effect size (Cohen's *f*) was set at small (f = 0.10), the number of measurements was set at 2 and the correlation between measurements was set to r = 0.9 (Routen et al., 2012b) to give a power of 80% using a within-between group design. The minimum sample size required, calculated with these parameters, was n = 54, which equates to n = 18 per group, with a power of 0.82.

Study design

Three classes of children were randomly assigned to one of three conditions: (a) individual-standardised goal group (IS), (b) group-standardised goal group (GS), or (c) open-pedometer control group (CON). Outcome measures were taken at baseline and intervention end-point. For IS and GS, baseline measurements were taken 2 weeks prior to the intervention due to a school holiday. Control group baseline measurements were taken the week preceding the intervention. The study was conducted in total over 9-weeks and consisted of three phases for each group: a 1-week baseline evaluation, a 3-week intervention and a 1-week endpoint evaluation.

Procedure

At baseline and end-point on the first day (Monday) anthropometric measures were taken and pedometers and Actiwatch 4 (AW4) accelerometers were distributed. The researcher demonstrated the correct placement of the pedometer and AW4. Children were instructed to wear both devices at all times except when engaging in water-based activities and when asleep in the case of the pedometer. The researcher returned to collect both units 5 days later (Friday).

Measurements

Physical activity

Actiwatch 4 (AW4, Cambridge Neurotechnology, Cambridge, UK) accelerometers were placed on the wrist (side at participant's discretion), and were set to record at 10-s epochs. Participants were instructed to wear the device for 5 consecutive weekdays. An Omron HJ-109-E or Omron HJ-104 pedometer (Omron Healthcare, Milton Keynes, UK) was affixed to the waistband of the participant's right hip (in line with the patella). Participants were instructed to wear the device for 5 consecutive weekdays. Weekend days were not measured due to an unexpected alteration to the initial data collection schedule.

Anthropometric measures

All anthropometric measurements were taken in the morning to standardise across participants (Routen et al., 2011). Height to the nearest 0.1 cm was measured using a portable stadiometer (Seca 214, Seca Ltd., Leicester, UK) and weight to the nearest 0.1 kg was measured using electronic weighing scales (HD 352, Tanita Corporation, Tokyo, Japan). Body Mass Index was calculated by dividing weight (kg) by squared height (m). Following the calculation of BMI-for-age (percentile) (Cole et al., 1995), participants were categorised as *underweight* (BMI ≤2nd centile), *healthy-weight* (>2nd centile to <85th centile), *overweight* (≥85th centile to <95th centile) or *obese* (≥95th centile). Due to the low number of cases in each category participants were dichotomised into *non-overweight* (N-OW) (<85th centile) and *at least overweight* (AL-OW) (≥85th centile) groups for analysis.

Intervention

Following baseline, daily step goals for the intervention were calculated. Participants in the IS group were set goals of +5% over individual average baseline steps, and participants in the GS group were set the goal of +5% over the group average baseline steps. On the first intervention morning the researcher verbally addressed intervention groups, outlining the intervention (discussed during a prior visit) and answered questions. Subsequently, participants were seen individually where they were given a pedometer, a step diary with their daily step goal inside and a pedometer instruction sheet. During this time the researcher explained the process of recording daily step totals and goal attainment within the step diary. On the first morning of the second intervention week the researcher returned, collected step diaries and issued a new diary (including revised step goal). Lost or broken pedometers were replaced. This process was repeated for the final intervention week. Step goals for both groups started at +5% over baseline for week 1 and increased to +10% at week 2 and +15% for week 3. Previous pedometer studies have set step goals between 5−10% (Croteau, 2004; Kang & Brinthaupt, 2009) and therefore, the selection of a 5% increase over baseline for each week of the intervention was deemed an achievable and appropriate target.

The control group was given an open pedometer to wear for the 3 weeks with no further contact or materials. The use of an open pedometer alone has not been shown to induce reactivity or behaviour change in children (Ozdoba et al., 2004;

Butcher et al., 2007). All children were reminded to wear their pedometer by their class teacher and all classes were provided with a sticker chart. To promote compliance to pedometer wear the children would receive a sticker to place on the chart each day of the week they presented their pedometer to the class teacher.

Data treatment and statistical analyses

Participants required 3 days of pedometer data to be included in analyses (Craig et al., 2010). A mean imputation method based on an individual information-centred (I-C) approach (Kang et al., 2009b) was used to replace missing data. Where no baseline step data were recorded, mean imputation (group information-centred methods (Kang et al., 2009b)) were used to create step goals for the GS condition. There were no participants in the IS group who returned fully incomplete baseline step data.

For AW4 data non-wear time was defined as periods of ≥20 min of consecutive zero counts (Esliger et al., 2005). Sleep time between 22:00 and 06:00 was removed to prevent dilution of mean counts (Esliger et al., 2005). Participants required ≥600 min of valid wear time on ≥3 weekdays for further analysis (Mattocks et al., 2008). Raw activity counts were converted into minutes of MVPA using the cut-points (≥175 cts.10 s^{-1}) of Ekblom et al. (2012), scaled to 10 sec epochs as per Routen et al. (2012a). Total activity counts and MVPA minutes were calculated as the sum total from valid days/number of valid days and mean counts per minute were calculated as the sum of counts from valid days/minutes of valid wear time. As wear time differed between baseline and end-point by ~33 min (p = 0.01) total counts and MVPA were adjusted for wear time (volume/hours of wear time) (Graves et al., 2010). PA outcomes were therefore total activity counts, TC (cts.hr^{-1}), minutes of MVPA per hour (min.hr^{-1}) and mean counts per minute, CPM (cts.min^{-1}). Participants were dichotomised using baseline TC (50th percentile split) as *less-active* (<39,852 cts.hr^{-1}) or *more-active* (≥39,852 cts.hr^{-1}).

Complete pedometer step data were available for n = 36 (72%), therefore only accelerometer data were used as an outcome in analyses. Participants who did not provide valid accelerometer data (n = 18) at baseline and/or end-point were excluded from analysis of baseline characteristics and any further analyses (see Figure 1).

All statistical analyses were conducted using SPSS 19.0 (Chicago, IL, USA). Baseline descriptives were calculated for all variables. Normality of variables was assessed per group using the Shapiro-Wilks test. Only BMI violated normality. A one-way ANOVA (Kruskal-Wallis for BMI) was used to determine differences in baseline characteristics between step-goal conditions and weight status groups. An independent samples t-test (Mann-Whitney U for BMI) was used to determine differences in baseline characteristics between ‘excluded’ and ‘final sample’ participants. A 3-factor repeated-measures ANOVA was used to determine the effect of time (two levels: baseline and end-point), condition (three levels: IS, GS and CON) and PA level (two levels: less-active or more-active) on outcomes. To investigate the main effects further, either independent or paired samples t-tests with Bonferroni adjustments were used. Where interactions were found, independent samples t-tests with Bonferroni adjustments were used. Independent t-tests were also used to compare change in PA outcomes (time) between weight-status groups within conditions. Alpha was set at $p < 0.05$ for all tests.

RESULTS

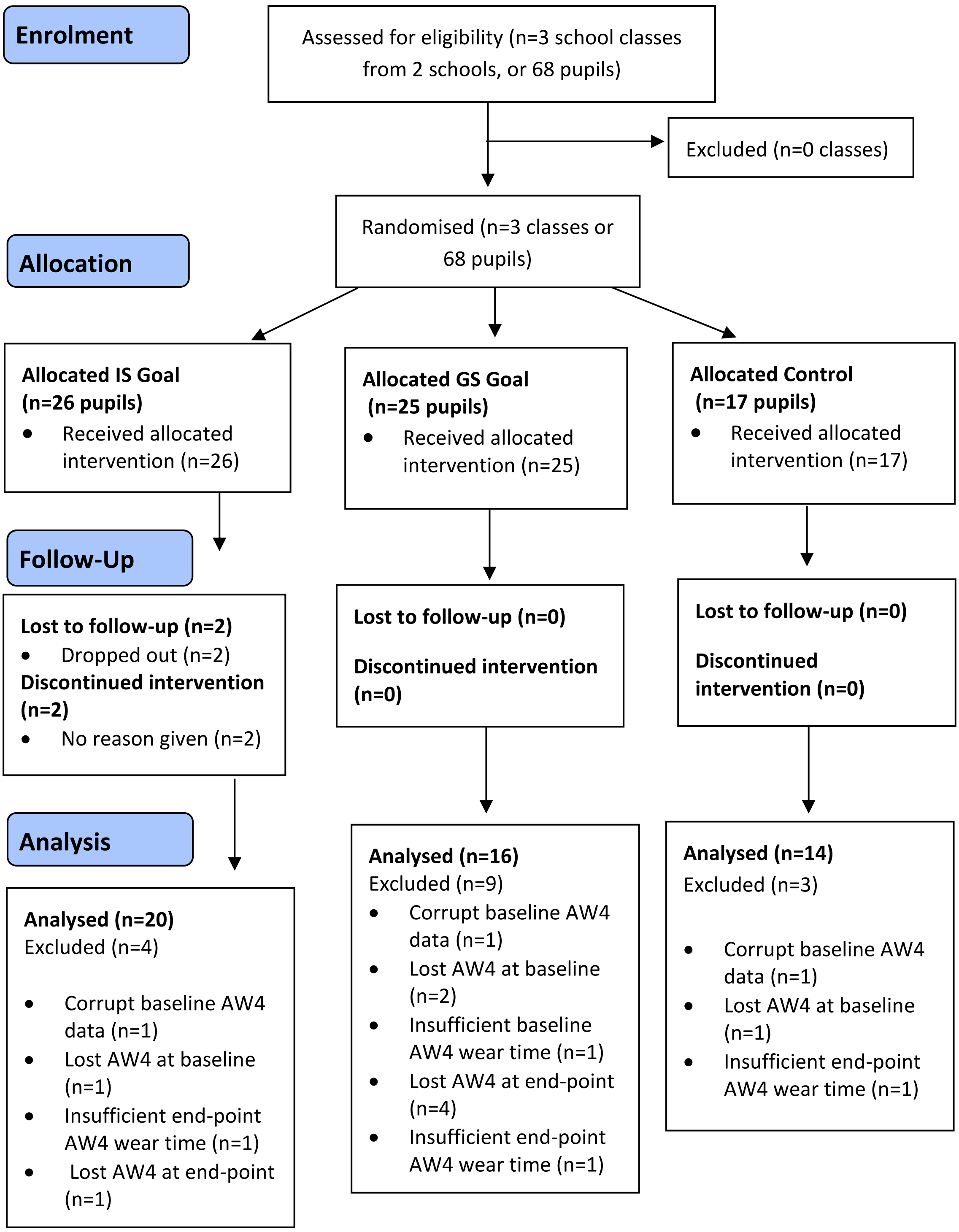

Figure 1: Participant progression through the study phases

From Figure 1, complete accelerometer data sets were available for 20 of the eligible 26 in the IS condition, 16 of the 26 in the GS and 14 of the 17 eligible in the control group condition. Reasons for exclusion at either baseline or end-point included lost AW4 units (*n* = 9), corrupt data files (*n* = 3), insufficient wear time (*n* = 4) and drop out (*n* = 2).

There were no differences in age ($p = 0.84$), BMI ($p = 0.28$), steps ($p = 0.15$), TC ($p = 0.98$), CPM ($p = 0.98$) or MVPA ($p = 0.71$) between 'excluded' ($n = 18$) and 'final sample' ($n = 50$) participants at baseline.

Baseline characteristics

Baseline characteristics for the final sample ($n = 50$) are shown in Table 1. There were no differences in age ($p = 0.43$), BMI ($p = 0.96$), steps ($p = 0.40$), TC ($p = 0.35$), CPM ($p = 0.35$) or MVPA ($p = 0.60$) between conditions. There were no differences in age ($p = 0.46$), steps ($p = 0.98$), TC ($p = 0.68$), CPM ($p= 0.68$) or MVPA ($p = 0.83$) between weight status groups (N-OW, AL-OW). There were no differences in age ($p = 0.05$) or BMI ($p = 0.23$) between *less-active* and *more-active* children.

Table 1: Participant baseline characteristics

	Individual-standardised (IS) *n* = 20	**Group-standardised (GS) n = 16**	**Control (CON) n = 14**
Age (years)	11.1 ± 0.3	11.3 ± 0.4	11.3 ± 0.3
Height (cm)	145.8 ± 6.7	146.0 ± 7.9	147.0 ± 8.6
Weight (kg)	41.7 ± 12.4	40.0 ± 9.3	40.0 ± 9.6
BMI ($kg.m^2$)	19.5 ± 4.8	18.6 ± 3.1	18.3 ± 3.2
Steps ($steps.day^{-1}$)	16,675 ± 5,133	18, 871 ± 3,887	18,457 ± 4,935
N-OW (%)	12 (60.0%)	10 (62.5%)	11 (78.6%)
AL-OW (%)	8 (40.0%)	6 (37.5%)	3 (21.4%)
Less-active (%)	9 (45.0%)	6 (37.5%)	10 (71.4%)
More-active (%)	11 (55.0%)	10 (62.5%)	4 (28.6%)

N-OW = non-overweight, AL-OW = at least overweight.

Table 2 presents means and standard deviations for all accelerometer-measured PA variables at baseline and end-point, as well as the difference between time points for all conditions.

Table 2: Physical activity variables for all time points and study groups.

Time point	Condition	Total counts ($cts.hr^{-1}$)	Counts per minute ($cts.min^{-1}$)	MVPA ($min.hr^{-1}$)
Baseline	IS	41,580.2 ±14,093.9	693.0 ± 234.9	13.4 ± 5.0
	GS	44,188.0 ± 9,254.6	736.4 ± 154.2	14.0 ± 3.1
	CON	38,259.2 ± 7,584.6	637.7 ± 126.4	12.5 ± 3.5
End-point	IS	42,238.9 ± 10,954.7	704.0 ± 182.6	14.1 ± 4.4
	GS	41,144.9 ± 7,816.9	685.8 ± 130.3	13.0 ± 3.2
	CON	34,665.7 ± 7,437.8	577.8 ± 124.0	11.0 ± 3.3
Time change (95% CI)	IS	658.7 (-3,105.6 to 4,423.0) *NS*	11.0 (-51.8 to 73.7) *NS*	0.8 (-0.5 to 2.1) *NS**
	GS	-3043.1 (-5,988.7 to -97.5) *NS*	-50.7 (-99.8 to -1.6) *NS*	-1.0 (-2.2 to 0.1) *NS*
	CON	-3593.4 (-6,496.8 to -690.1) *NS*	-59.9 (-108.3 to -11.5) *NS*	-1.6 (-2.8 to -0.3) *NS*

NS = No significant time change ($p > 0.05$). *Difference in MVPA change between IS and CON ($p = 0.01$).

Main effects

Maulchly's test for sphericity was not computed for within-subject effects, as this assumption is met when the number of levels is two or less (Field, 2005). Levine's test for equality of variance was not significant for any of the PA outcomes ($p > 0.05$).

The main effect of time was significant for TC ($F(1,44) = 4.6$, $p = 0.04$) and CPM ($F(1,44) = 4.6$, $p = 0.04$), but not MVPA ($F(1,44) = 3.5$, $p = 0.07$). Bonferroni-adjusted paired *t*-tests revealed no differences in TC, CPM or MVPA between baseline and end-point in all conditions ($p > 0.016$). However, TC ($p = 0.019$), CPM ($p = 0.019$) and MVPA ($p = 0.016$) were approaching a significant decline in CON.

The main effect of condition was not significant for TC ($F(2,44) = 0.5$, $p = 0.60$), CPM ($F(2,44) = 0.5$, $p = 0.60$) or MVPA ($F(2,44) = 0.2$, $p = 0.80$).

The main effect for baseline PA level was significant for TC ($F(1,44) = 44.1$, $p = 0.01$), CPM ($F(1,44) = 44.1$, $p = 0.01$) and MVPA ($F(1,44) = 44.4$, $p = 0.01$). As expected TC (45,673.7 ± 7,851.4 vs 33,863.0 ± 7,099.3 $cts.hr^{-1}$, $p = 0.01$), CPM (761.2 ± 130.9 vs 564.4 ± 118.3 $cts.min^{-1}$, $p = 0.01$) and MVPA (15.3 ± 3.2 vs 10.5 ± 3.1 min, $p = 0.01$) were greater in *more-active* children at end-point.

Interaction effects

There was an interaction between time and condition for MVPA ($F(2,44) = 5.8$, $p = 0.01$), but not TC ($F(2,44) = 3.3$, $p = 0.05$) or CPM ($F(2,44) = 3.3$, $p = 0.05$). The change in MVPA did not differ (Bonferroni-corrected alpha = 0.167) between IS and GS ($p = 0.04$) or GS and CON ($p = 0.56$). Change in MVPA differed between

IS and CON (p = 0.01). MVPA increased in IS children by 0.8 ± 2.8 min, whilst MVPA decreased by -1.6 ± 2.1 min in CON.

There were no interactions between baseline PA and condition for TC (F(2,44) = 1.9, p = 0.16), CPM (F(2,44) = 1.9, p = 0.16) or MVPA (F(2,44)=2.3, p = 0.12). There were also no interactions between baseline PA, time and condition for TC (F(2,44) = 0.1, p = 0.92), CPM (F(2,44) = 0.1, p = 0.92) and MVPA (F(2,44) = 0.1, p = 0.93). From Figure 2 TC increased in *less-active* children in both IS and GS, and decreased in CON. In *more-active* children TC declined in all groups.

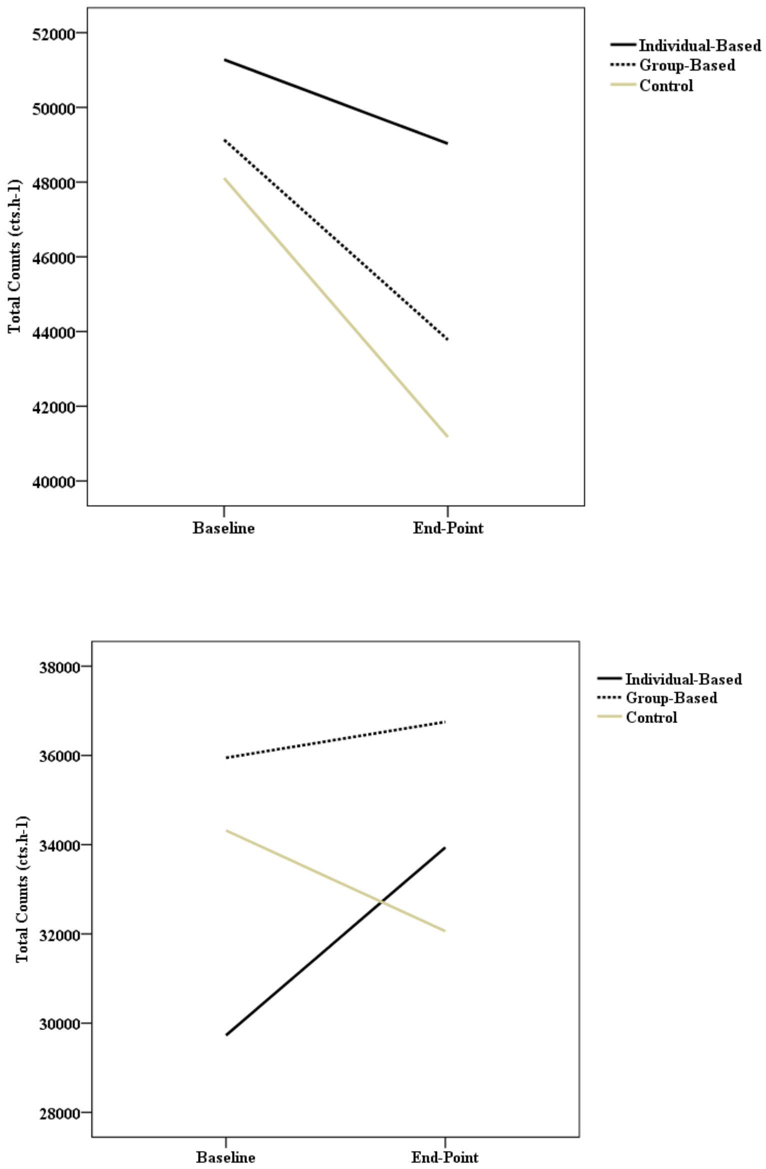

Figure 2: Total activity counts (TC) for *more-active* (top panel) and *less-active* (bottom panel) children in all conditions. Values are means, error bars are not shown for ease of interpretation

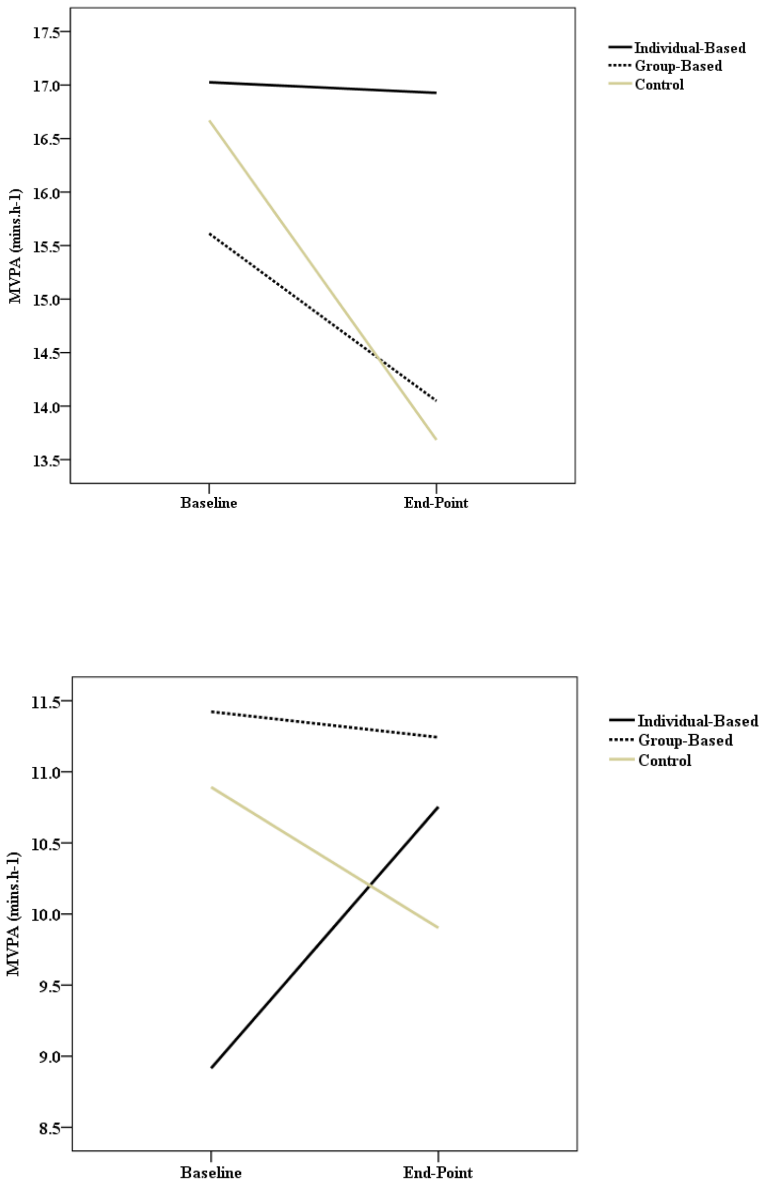

Figure 3: MVPA for *more-active* (top panel) and *less-active* (bottom panel) children in all conditions. Values are means, error bars are not shown for ease of interpretation

From Figure 3, MVPA increased in *less-active* children in the IS, whilst decreasing in GS and CON. MVPA in *more-active* IS children did not change, whilst it decreased in GS and CON.

Weight-status moderation

There were no differences in change in TC, CPM or MVPA between N-OW and AL-OW children within any condition ($p > 0.05$).

DISCUSSION

The primary aim of this intervention study was to examine the impact of a 3-week pedometer-based intervention upon accelerometer-measured PA. Results showed that there were no differences between groups in PA at intervention end-point and no change in PA as a result of the intervention. This suggests that a combination of step feedback, goal setting and self-monitoring alone may not be sufficient to increase PA in children.

The failure of this intervention to increase PA is not consistent with prior pedometer work in children. For example, both 'Fit 'n' Fun Dude' interventions (Hardman et al., 2011; Horne et al., 2009) employed goal setting, self-monitoring and feedback strategies in similar age British children and observed increases of ~2−3,000 steps.day^{-1} over baseline. Both of those interventions, however, also included peer modelling, tangible and contingent rewards as well as maintenance phases. The only comparable study, by Kang and Brinthaupt (2009), tested a 6-week step feedback, goal-setting (IS and GS) and self-monitoring intervention. Across step-goal conditions there was a 19% increase in steps from baseline (5,454 ± 1,432 steps.day^{-1}) to end-point (6,478 ± 2,053 steps.day^{-1}). However, the intervention duration was two times greater than the current study and children only wore pedometers within the school day. In addition, step goals were set as increments of the previous two weeks' step count as opposed to goals derived from per cent over baseline. This disparity in findings implies that the effectiveness of combining feedback, goal setting and self-monitoring is unclear, and warrants further examination.

There were no main effects for step-goal condition, or an interaction between time and condition (except for MVPA), suggesting that IS and GS goal setting were equally ineffective. The congruence in impact between step-goal conditions is comparable to the findings of Kang and Brinthaupt (2009). They reported no differences in daily step totals between children assigned to IS and GS conditions at intervention end-point. In adults, Sidman et al. (2004) observed no group differences at intervention end-point in adult women assigned either a personalised standardised goal (self-set increment over baseline) or a universal (10,000 steps.day^{-1}) goal. Previous reviews of interventions in adults have reported similar effect sizes (ES) for individual- and universal/group-standardised goals. Kang et al. (2009a) found adult studies using a strategy of 10,000 steps.day^{-1} had the highest effect size (ES; 0.84), while those prescribed individualised goals (mixed adult and child data) had a lower ES of 0.72.

Prior studies in children (Kang & Brinthaupt, 2009) and adults (Sidman et al., 2004; Sidman et al., 2003) have suggested goal attainment (i.e., meeting the goal) may be dependent upon both goal type and baseline PA. Kang and Brinthaupt (2009) found goal attainment to be higher in low-active children prescribed IS (16.4 ± 3.1 attainments) than in those GS (6.2 ± 4.9), but there were no differences between conditions for medium- or high-active children. Sidman et al. (2003) found that very-low active and low-active women assigned a universal goal (10,000 steps.day^{-1}) achieved their goals on fewer occasions compared with more-active women. In addition, Sidman et al. (2004) reported low-active women assigned a universal step goal (10,000 steps.day^{-1}) had lower attainment compared with both medium- and high-active women, and compared with all activity levels in women assigned a self-selected individual-based goal. These data suggest that goal attainment appears to be dependent upon baseline PA level, with limited evidence that individual-based goals may be more appropriate for low-active children (Kang and Brinthaupt, 2009). Interestingly, lower goal attainment did not result in any differences in daily step totals between low-active children in either goal condition at end-point in the study by Kang and Brinthaupt (2009). In the study by Sidman et al. (2004) there were also no differences in daily step totals in women assigned either a universal or personalised step goal at end-point. In the present study there were an insufficient number of step-goal diaries returned to permit meaningful analysis of goal attainment.

There were no interactions between baseline PA, time and condition. However, from Figures 2 and 3 total PA (TC) increased in *less-active* children markedly in the IS condition (~4,000 $cts.hr^{-1}$) and marginally in the GS condition (~500 $cts.hr^{-1}$). *More-active* children's TC declined in all conditions. The decline in *more-active* children may result from a ceiling level whereby initial increases in PA are unsustainable, and accordingly PA levels regress. If children failed to meet step goals in week 1, the goal in week 2 and 3 was increased regardless as it was derived as an increment over baseline. This would have increased the difficulty of goal attainment. Goal attainment has not been found to influence end-point steps in prior studies (Kang & Brinthaupt, 2009; Sidman et al., 2004), but the present study population may be less resistant to goal failure. Reduced goal attainment and negative step feedback in *more-active* children may have reduced self-efficacy, a known mediator of children's PA (Lubans et al., 2008), negatively impacting on motivation. The greater decline in TC in *more-active* children assigned GS may also be because some children in GS were set lower goals than baseline values, thus offering no motivational stimulus.

Interestingly MVPA increased (~1.5 $min.hr^{-1}$) in *less-active* children prescribed IS but decreased marginally in those prescribed GS. In *more-active* children MVPA appeared stable in the IS, but declined markedly in GS and CON. *Post-hoc* tests revealed the change in MVPA differed between IS and CON. MVPA increased in IS children by 0.8 ± 2.8 min, whilst MVPA decreased by -1.6 ± 2.1 min in CON. It appears that consistent with previous data (Oliver et al., 2006) the primary driver of response to this intervention was baseline PA, with IS goal setting to some extent mitigating the unfavourable response in those *more-active*. There were however, no main effects for step-goal condition, or time x condition x PA level interactions. Regarding this interaction, *post-hoc* power values revealed that the current sample size did not have sufficient power to detect effects in this sub-group analysis. Despite low power, analysis-of-means plots provide tentative evidence that IS may be more suitable for both *less-active* and *more-active* children, but appears to impact to a greater extent on *less-active* children.

Analysis of change in PA between *non-overweight* and *at least overweight* within each condition revealed no differences between groups. Despite the small number of cases in each category, this analysis provides evidence that children of differing BMI-determined weight-status groups did not respond differently to the intervention. However, as this analysis was likely underpowered and previous pedometer studies have called for the examination of weight status as a moderating variable (Horne et al., 2009; Tudor-Locke & Lutes, 2009) it is important for future studies to examine this further.

The change in MVPA observed between baseline and end-point, across all conditions was not significant and thus may not appear instantaneously meaningful. In the IS, MVPA increased by 0.8 (95% CI: -0.5 to 2.1) $min.hr^{-1}$ (p = 0.23), in the GS it decreased by -1.0 (95% CI: -2.2 to 0.1) $min.hr^{-1}$ (p = 0.07) and in the CON it decreased by -1.6 (95% CI: -2.8 to -0.3) $min.hr^{-1}$ (p = 0.02). However, when multiplying these values by the mean wear time from both time points (15.0 ± 0.6 hr), the decrease in MVPA in the GS was ~15 min and ~24 min in the CON. When considering that a difference of ~15 min of MVPA has been shown to reduce the odds of obesity in similar age children (Ness et al., 2007; Riddoch et al., 2009), this is a biologically meaningful decline in PA. Therefore, the fact that the IS condition maintained MVPA is arguably as important as a behavioural increase. Indeed, due to limited funding and resources, and the age-related decline in PA, there have been suggestions that preference should be given to maintenance as opposed to promotion (Jago, 2011).

There are numerous factors that may explain the failure of this intervention to improve PA. The intervention duration was limited to 3 weeks to accommodate school term structures and data collection feasibility, and may not have been of sufficient length. Nonetheless, short-duration pedometer interventions have reported significant increases in step counts over baseline (Butcher et al., 2007; Shimon & Petlichkoff, 2009). It is also plausible that any initial increases in PA had diminished by intervention end-point. Yet this hypothesis is unfounded as mid-point PA evaluations were not conducted. When considering that the staggered baseline evaluation meant that the study ran from May to July 2011, it is also surprising that PA declined in the CON condition, when an increase in daylight hours would have provided more opportunity for outdoor play/activities (Goodman et al., 2012).

That this intervention did not increase PA serves to strengthen arguments that multiple levels of influence on PA should be targeted to provide maximum likelihood for increasing PA (Van Der Horst et al., 2007). Systematic reviews of youth interventions have emphasised the importance of the physical environment, altering policies and parental/familial involvement for PA modification (Kriemler et al., 2011; van Sluijs et al., 2008). School-based interventions may be limited in their ability to address wider social and physical environment influences, but there are factors that could be included within school-based interventions including the introduction of playground markings (Ridgers et al., 2010), standing desks (Benden et al., 2011) and active class rooms (Lanningham-Foster et al., 2008). To increase the likelihood of a positive effect, future interventions delivered in schools should implement environmental modifications (Routen, 2011) and involve parents/significant others (Barber et al., 2013; Nixon et al., In Press) to create a more supportive environment.

This study has several limitations. The final study sample did not have sufficient power to be able to detect change in PA when sub-group analyses were conducted. Further, the two intervention groups were recruited from within the same school and therefore open to crossover contamination effects; however, the dissimilar time change in PA at the sub-level (i.e., baseline PA) between groups suggests contamination may have been minimal. A particular limitation was the measurement of only weekday data; therefore, possible intervention effects on weekend days were missed. Future interventions should capture weekend data as there are known differences in PA pattern between weekdays and weekend days in some populations (Rowlands et al., 2009).

The strengths of this study are that the PA outcomes were generated using AW4 accelerometers that had previously been laboratory tested and found to exhibit good reliability (i.e., CV~5%) (Routen et al., 2012b). These devices were affixed to the same position, and where possible the exact same model was used for each participant at each time-point to minimise artificial data variance. The low number of invalid accelerometer data files (i.e., insufficient wear time) provides indirect evidence for acceptability of wrist-worn activity monitors. This is the first study to employ a wrist-worn accelerometer to measure PA in a field-based pedometer intervention in children. Pedometers are limited by their inability to provide a measure of PA intensity and pattern, which are key outcomes for determining activity-health relationships. Where possible future pedometer-based interventions should utilise activity monitors capable of capturing these dimensions of PA (Harris et al., 2013).

CONCLUSION

In conclusion, this intervention is the first to examine the impact of pedometer-based self-monitoring, feedback and goal setting *per se* against pedometer-wearing controls. It is also only the second study to examine the importance of step-goal type in children. The primary findings were that in the whole sample a combination of pedometer-based self-monitoring, feedback and goal setting did not lead to an increase in PA. Despite no difference in PA or PA change between step-goal conditions, there was a trend towards IS goal setting maintaining PA volume and MVPA in *more-active* children, and increasing PA volume and MVPA in *less-active* children; whereas in children prescribed a GS goal there was a marginal increase in PA volume in *less-active*, a marked decline in *more-active*, and declines in MVPA in both *less-active* and *more-active* children. These data provide tentative findings to suggest that IS goal setting is more effective than GS for improving PA using pedometer programming, and is less influenced by baseline PA level. Future studies should determine if this difference is related to goal attainment (i.e., achievement of daily step goal). Further work should also utilise larger samples to determine if PA level and weight status moderate the main intervention effect, and further, compare alternative goals against the IS approach (i.e. Individual-standardised vs self-set/tailored, individual-standardised vs generic etc.). Most important, however, is clarification of the effectiveness of goal setting, self-monitoring and step-feedback pedometer-based interventions *per se* for changing physical activity in children.

FIRST AUTHOR'S BIOGRAPHY

Ash Routen is now a Postdoctoral Research Associate in the School of Education at Durham University, UK. His research interests include physical activity and sedentary behaviour measurement and the use of randomised controlled trials to evaluate health and well-being interventions in children. The research presented in this manuscript formed part of his PhD studies completed in the Institute of Sport and Exercise Science at the University of Worcester under the supervision of Professor Derek Peters. The data for this research was collected between May and July 2011.

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